

Contribution ID: 270

Type: **Presentazione orale**

Vibration Fatigue under Sine-on-Random Loading: A comparative analysis of the predictive capability and application limits of spectral methods

Wednesday 2 September 2026 14:30 (15 minutes)

In several industrial sectors, primarily aerospace and defense, mechanical components are frequently subjected to Sine-on-Random (SoR) loading. Such processes are characterized by a marked non-Gaussianity that limits the applicability of conventional spectral methods for fatigue damage estimation. This study critically analyzes the primary frequency-domain strategies currently available, comparing approaches based on cycle distribution with equivalent PSD based methods.

The evaluation is conducted by benchmarking these strategies against time-domain analyses using profiles defined by industry standards, in order to quantify the accuracy, robustness, and computational cost of each approach. The results highlight the predictive capability and operational limits of the considered techniques and provide practical selection criteria based on the specific characteristics of the SoR signal.

Building on these findings, an alternative strategy based on the equivalence of spectral moments is also outlined.

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Session Classification: Fatica e Frattura

Track Classification: Fatica e Frattura